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THE MTS DATA COLLECTION FACILITY

Tad B. Pinkerton

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T H E U N I V E R S I T Y O F M I C H I G A N

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THE MTS DATA COLLECTION FACILITY

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I. BACKGROUND

In order to understand the character of the data collection facility, it is necessary to know something about the structure of MTS. The MTS system is built on top of a multiprogramming supervisor called UMMPS. UMMPS executes jobs, which are initiated and controlled from the operator's console typewriter. Each job runs in problem state and uses supervisor calls for all its input and output operations.

The basic set of instructions (which is executed when an UMMPS job is initiated) is called a job program. Job programs are core-resident. They include the specification of a set of device types and memory buffers of various sizes. When a job is activated, actual devices and memory space are allocated to fit the specifications. By means of supervisor calls, jobs may obtain and release additional devices and space during execution.

MTS is a reentrant job program in UMMPS. It provides the capability of loading, executing, and controlling other programs, and offers a system of line files for the online storage of programs and data. An MTS job is distinguished by the fact that it can use virtual storage: jobs using any other job program acquire and release main core storage. UMMPS makes use of the dynamic relocation hardware peculiar to the System/360 Model 67 to provide each MTS job with a virtual memory

space of 256 pages (one page = 4096 bytes). The supervisor manages core storage with a demand paging algorithm, using an IBM 2301 Drum (and eventually the 2314 Disk) for secondary storage. The paging drum processor runs as a separate (non-MTS) job in UMMPS.

II. STRUCTURE

At appropriate points in UMMPS and the MTS job program, instructions have been added to supply data about system and program operation. Data are actually collected by a supervisor subroutine, which is called from a number of points in the supervisor and can be invoked in problem state (e.g., in the MTS program) via a supervisor call.

The UMMPS subroutine places data item and job identification, the time, and specific item data into buffers allocated to a job called STAT which must be active in order for data collection to take place. The STAT job links and manages the emptying of its buffers onto magnetic tape, controls the type and origin of the data to be collected, and places additional data items in the buffer specifying the jobs from which the data were taken.

Tapes of MTS data are processed by a program in the MTS file *ANALYSIS, which is essentially a general-purpose filter for selecting items from the tape, together with a data-reduction analysis to decode overall states of a program (e.g., execution, I/O wait) from the standard supervisor data items.

III. CAPABILITIES

Some two dozen kinds of system data items can now be routinely collected by invoking this facility. In addition, an assembly-language programmer can supply his own data by executing the appropriate SVC instruction. Transitions to and from the CPU wait state can be recorded.

Each item of data contains a five-byte clock value, which is the number of (high-resolution) timer units since midnight. A timer unit is 13 1/48 microseconds. By performing repeated experiments and making appropriate allowances for the overhead introduced by the data collection facility itself, it is in some cases possible to clock events of a duration shorter than a single timer unit.

IV. PROCEDURES FOR TAKING DATA

Data collection is initiated by mounting one or two (7 or 9) track tapes and starting the STAT job at the operator's console. If only one tape is specified the job is automatically terminated when it is full. Reel switching occurs back and forth between a pair of tapes.

A second UMMPS job called STATSW is invoked once STAT is running when one wishes to alter the designation of jobs or items for data collection. Except for the absence of tape device names, the parameters for STATSW are exactly those of STAT.

The first STAT parameter must be a tape name. If two tapes are used, the second parameter must specify the second tape name. The remaining parameters give

a. job numbers of jobs for which data are to be collected,

b. item numbers of data items which are to be collected for the specified jobs,

c. global parameters to specify groups of jobs or items,

d. and parameters which precede the lists of job/item numbers and indicate the way in which they should be used.

A job number is a unique positive integer assigned by UMMPS whenever a job is initiated at the operator's console typewriter. Each line on the console sheet is prefaced by the job number to which the line applies. The TASKS job lists all active jobs and their corresponding job numbers. The job number of an MTS job is also printed in the greeting line at a remote terminal.

An item number is an integer between 0 and 31. Items of type 0 and 1 are always collected. The definitions of the remaining item types (except for the unused types) are given in Appendix A.

The global parameters used to specify groups of job and item numbers are ALL, NONE, and MTS. The MTS parameter

applies only to job numbers, and means all UMMPS jobs that use the MTS job program.

The following parameters precede lists of numbers and global parameters: JOBS, meaning that a subsequent parameter is a job number or job global parameter; ITMS, meaning that a subsequent parameter is an item number of item global parameter; ¬ JOB, meaning that data collection is to be turned off for the immediate following list of job numbers; ¬ ITM, meaning that the specified data items are not henceforth to be collected for whatever jobs are later designated.

The default assignment of parameters is

JOBS NONE ITMS ALL ,

hence no data collection will take place unless at least one job number is designated, but all items will be collected for whatever jobs are given.

In MTS the CPU time in wait state and interrupt processing unassigned to jobs is charged to a dummy job whose job number is zero. If job 0 is specified for data collection then all transitions to and from wait state can be recorded.

V. TAKING SPECIAL DATA

By means of the supervisor call

```
        SVC    STATENT
STATENT EQU    44
```

an assembly-language program can cause a special data item to be inserted in the STAT buffers. This SVC assumes that general registers zero and one contain the appropriate identification and data address:

GR0: The ID and length (in words) of the entire data item, in the form

ID*8+LENGTH-1 .

The length includes the two words added to the front of special data by the supervisor, and the entire item may be no more than eight words long.

GR1: The address of the third and succeeding words, if any, of the data item.

The SVC writes a data item only if the issuing job has data collection for the given ID (item number) designated. One item type (#23) is specifically reserved for the use of system programmers for the collection of special data, and in general it should be used, since any other type may be assigned

to a standard system function. As an example, then, if one wanted to collect the two words of data at the location MARK in his program, the required code is

```
LA    0, 23*8+4-1
LA    1, MARK
SVC   STATENT
```

since the total item length will be four words.

VI. DATA ANALYSIS

The MTS file *ANALYSIS contains the object module of a general-purpose data reduction program, which can be used to

(1) Print the annotated and interpreted data items just as they were placed on the tape.

(2) Reduce the standard system data items to a sequence of ready, active and wait intervals for each job, together with relevant additional information abstracted from the data.

(4) Call a subroutine at the point where each ready, etc. interval would be printed out, with a pointer to the entire job description at that instant.

(8) Write the output on tape.

(16) Call a subroutine for each item having to do with paging data.

(32) Print a data-reduced description of each paging item.

(64) Call a subroutine for each item as it is received from the data tape.

(128) Print a one-line description of each record on the data tape.

These output options and a number of other actions are invoked by specifying a combination of the following keyword parameters following "PAR=" in the $RUN command for *ANALYSIS. The parameters must contain no blanks, and integers are not checked for validity:

OPTN = integer

The integer (between 0 and 255) specifies the desired output options from the above list. It is the sum of the option numbers (in parenthese above) of the desired types of output. The default case is

OPTN = 161

or, in other words, all options (1, 2, 32, 128) which provide printed output, but no others.

SFIL = integer

This integer specifies the number of files to be skipped on the input tape. Default = 0.

CFIL = integer

The number of files of data to be converted from the tape. Default = 1 .

SREC = integer

The number of records (one record = about 350 items) to be skipped on the tape. The default is zero.

CREC = integer

The number of records to be converted from the tape. Default = one entire file.

SITM = integer

The number of items to be skipped on the tape. Default = 0.

CITM = integer

The number of items to be converted from the tape. Default = one entire file.

ITMS = A list of item numbers separated by commas

This list specifies the item types which are to be converted from the data tape. All others are skipped entirely. The default case is to convert all items.

¬ITM = list

This list specifies the item types which are not to be converted from the data tape. When this parameter is used all other types are converted.

JOBS = list

A list of job numbers of UMMPS jobs whose items are to be converted. Items for other jobs are skipped entirely. The default case is no jobs, except that the occurrence of a STATSW item (#7) in the data automatically begins conversion for the job for which it was collected. STATSW items are placed in the data by the STAT and STATSW jobs whenever recording is designated for a job. The word ALL may be written instead of a job number list.

MFMT = format

The MFMT parameter, if used, must be the last to appear in the parameter list, and its value can be up to 100 characters long. This parameter supplies a format for printing MARK items (#23). The standard format of item code, job number, interval time, etc. appears at the head of the line, and the given format is used to control the printing of the (up to 6) words of variable information which may be included in a data item. Eighty-eight columns are available for the output image. The print format call on IOH/360 specifies those six words as a block, preceded by the (halfword) length of the data (in words) in this particular occurrence of the item. The default parameter specification is

I4H,C24,S-28*

but the count can be used with a list-type format variable to

print only the existing data, e.g.,

V(X8.S2),8(BX0)*

prints the data in hexadecimal words separated by pairs of blanks.

PARM = anything

The address of this parameter is passed to the initialization entry of subroutines called by the *ANALYSIS program. It is terminated by the first blank to appear after the keyword and equal sign. Like the MFMT parameter, this parameter, if used, must be the last to appear in the parameter list.

General Notes:

a. SREC and SFIL are processed as soon as they are decoded in the parameter list. Hence they should be placed in the intended order when they are both specified.

b. The STATSW items which cause *ANALYSIS to begin converting items for a particular job typically occur at the very beginning of the data. If, however, these items are eliminated via ITMS of -ITM, then the JOBS parameter must be used to indicate which jobs are to have their data converted.

c. The SITM and CITM counts apply only to the types of items being converted.

d. The *MOUNT program must be run for the STAT data tape, since the records range up to 4084 bytes in length.

e. Four unlabeled numbers appear on the leader line of each page of *ANALYSIS output: they are the current input tape record, selected item count, total item count, and time for first item on the page, respectively. The record and selected item counts do not include skipped data, but the total item count includes those skipped with the SITM parameter.

Appendix B shows an example of the MTS commands necessary to use the *ANALYSIS program.

VII. ANALYSIS SUBROUTINES

Options (4), (16), and (64) for the analysis program provide for calling subroutines and supplying them with appropriate data. The names and functions of the expected routines are given below. If any subroutine option is specified, one supplies his own object modules concatenated with *ANALYSIS (1,500): the latter file has existing definitions for the subroutine names beginning at line 501.

OPTN	ROUTINE	PARAMETERS
Initialization	STP2A	PARM
4	STP2B	JOBAREA, ITEMAREA
16	STP2C	JOBAREA, ITEMAREA, PAGEAREA
64	STP2E	JOBAREA, ITEMAREA
Termination	STP2D	-

The initialization and termination entry points are called by *ANALYSIS if at least one of the subroutine options

is given. The ITEMAREA contains the input item exactly as taken from the data tape. The formats for JOBAREA and PAGEAREA are given in Appendix C.

VIII. EXAMPLES

Appendix D shows examples of the various kinds of output obtained from the *ANALYSIS program and some of the subroutines written to be called by it. Each sample is prefaced by a short description.

APPENDIX A

STANDARD DATA ITEMS COLLECTED WITH STAT...

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PARTS OF THE DATA ITEMS WHICH ARE NOT DESCRIBED BELOW ARE NOT USED OR CONTAIN MEANINGLESS DATA.

EACH STANDARD ITEM BEGINS WITH A TWO-WORD PREFIX: THE ID AND LENGTH IN BYTE 1 IN THE FORM ID*8+LEN-1, THEN THE LOW-ORDER TIMER BYTE IN BYTE 2. THE JOB NUMBER OCCUPIES BYTES 3-4, AND THE TIMER WORD IS IN BYTES 5-8.

NOTE: THE FIRST TWO ITEMS ARE PLACED IN THE BUFFERS BY STAT ITSELF AND DO NOT HAVE THE STANDARD PREFIX DESCRIBED ABOVE.

NAME	ID/LEN	DESCRIPTION
OVERFLOW*	0/1	THE SECOND HALF-WORD OF THIS ONE-WORD ITEM CONTAINS A COUNT OF THE NUMBER OF ITEMS WHICH WERE MISSED AT THE POINT OF OCCURRENCE BECAUSE THE STAT JOB COULD NOT KEEP UP.
DATE*	1/3	WORDS TWO AND THREE OF THIS ITEM CONTAIN THE EBCD DATA OBTAINED FROM THE SYSTEM AND PLACED IN THE FIRST BUFFER BY THE STAT JOB.
ADTOTP	2/3	THIS ENTRY OCCURS WHEN A NEW ENTRY IS ADDED TO THE TOP OF THE CPU QUEUE FOR THIS JOB. BYTE 9 CONTAINS THE INDEX OF THE NEW CPU Q ENTRY, AND BYTES 10-12 CONTAIN ITS ADDRESS.
POPQ	3/3	THIS ENTRY OCCURS WHENEVER AN ENTRY IS REMOVED FROM THE TOP OF THE CPU QUEUE FOR THIS JOB. BYTE 9 HAS THE INDEX AND BYTES 10-12 THE ADDRESS OF THE NEW TOP OF Q ENTRY, AS ABOVE.

NAME	ID/LEN	DESCRIPTION
WAYT	4/4	A WAYT ENTRY OCCURS WHEN A JOB ENTERS WAIT STATE AT ITS TOP CPU Q LEVEL FOR ANY REASON. BYTE 9 CONTAINS THE INDEX OF THE NEXT LOWER WAYT Q ENTRY, AND BYTE 10 THE INDEX OF TI E CPU Q ENTRY CORRESPONDING TO THE NEW WAYT. BYTES 11-12 CONTAIN THE HEX VALUE OOFF IF THE WAIT WAS NOT FOR I/O, OTHERWISE THEY CONTAIN THE DEVICE ADDRESS. BYTES 13-16 CONTAIN THE FLAG AND ADDRESS SPECIFYING THE LOCATION OF A WAIT BYTE.
UNWAYT	5/3	WHENEVER A JOB STOPS WAITING FOR ANY EVENT AT ANY CPU QUEUE ENTRY, THE INDEX OF THE TOP REMAINING WAYT Q ENTRY IS GIVEN IN BYTE 9, AND THE ADDRESS IN BYTES 10-12.
Q	6/3	THIS TYPE OF ITEM IS RECORDED WHENEVER THE JOB GIVEN BY THE NUMBER IN BYTES 3-4 RELINQUISHES THE CPU TO THE JOB WHOSE NUMBER IS IN BYTES 11-12.
STATSW	7/4	THE JOB NUMBER GIVEN IN BYTES 11-12 IS THAT OF A JOB WHOSE STATUS WITH RESPECT TO DATA RECORDING HAS JUST CHANGED. RECORDING HAS JUST BEGUN IF BYTE 9 IS ZERO AND HAS JUST ENDED IF BYTE 9 IS FF. BYTES 13-16 CONTAIN THE RECORDING BITS USED IN THE JOB TABLE FROM THIS POINT ON DURING COLLECTION.
PAGINSTR	8/5	WHEN A PAGE-IN OPERATION IS STARTED THE FOLLOWING IS GIVEN: THE REAL CORE PAGE ADDRESS IN BYTES 8-9, THE VIRTUAL MEMORY PAGE ADDRESS IN BYTES 10-11, THE PAGE CONTROL BLOCK STATUS BITS IN BYTE 12, THE NUMBER OF PAGE-WAITS FOR THE JOB IN BYTE 13, THE NUMBER OF REAL PAGES FOR THE JOB IS BYTE 14, THE STORAGE KEY AND OTHER BITS IN BYTE 16, THE PDP AND ADDRESS FLAGS IN BYTE 17, AND THE EXTERNAL (TRACK, SLOT) ADDRESS IN BYTES 18-19. SEE THE FILE *PCBDSECT FOR MORE INFORMATION ABOUT THESE BITS OF INFORMATION.
PAGINDON	9/5	WHEN A PAGE-IN OPERATION IS COMPLETED THE SAME DATA DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.
PAGOUTST	10/5	WHEN A PAGE-OUT OPERATION IS INITIATED THE SAME DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.

NAME	ID/LEN	DESCRIPTION
PAGOUTDN	11/5	WHEN A PAGE-OUT OPERATION IS COMPLETED THE SAME DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.
PAGRECLM	12/5	IF A PAGE IS RECLAIMED DURING PAGE-OUT THE VERY SAME DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.
GETVMPAG	13/5	WHEN A NEW VIRTUAL MEMORY PAGE IS ALLOCATED THE SAME DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.
FREVMPAG	14/5	WHEN A VIRTUAL MEMORY PAGE IS RELEASED THE VERY SAME DATA IS GIVEN AS FOR 'PAGINSTR' ABOVE.
MARK	23/?	THIS ENTRY IS RESERVED FOR THE USE OF SYSTEM PROGRAMMERS IN THAT IT IS THE ONLY ONE GUARANTEED TO BE UNASSIGNED TO SOME STANDARD SYSTEM FUNCTION, AND IS 'WATCHED FOR' BY THE *ANALYSIS PROGRAM SO THAT IT APPEARS WITH INTERVAL TIMING ON THE OUTPUT FORMAT, AND IS APPROPRIATELY MARKED ON INPUT FORMAT.
VMPAGES	24/5	WHENEVER THE NUMBER OF HALF-PAGES USED BY SOMEONE EITHER INCREASES OR DECREASES, AN ENTRY APPEARS TO GIVE THE CURRENT VALUE OF THE SPACE-TIME INTEGRAL IN 300THS OF A SECOND TIMES HALF-PAGES IN BYTES 9-12 AND THE TIME OF DAY WHEN THE VALUE LAST CHANGED IN BYTES 13-16, WITH THE CURRENT (NEW) NUMBER OF HALF PAGES IN BYTES 17-20. NOTE THAT THIS IS A VIRTUAL, NOT REAL, STORAGE USE INTEGRAL.
WAITFOR	25/2	A MINIMAL ENTRY IS MADE WHENEVER AN MTS USER SIGNS OFF, LEAVING THE JOB FOR SOMEONE ELSE.
UNLOAD	26/7	WHEN THIS TYPE OF ITEM APPEARS A PROGRAM HAS JUST BEEN UNLOADED IN MTS. ITS NAME IS GIVEN IN BYTES 9-24 AND THE STORAGE INDEX NUMBER CORRESPONDING IS IN BYTE 25.
LOAD	27/7	THE INFORMATION PROVIDED ABOVE FOR AN UNLOAD IS ALSO GIVEN FOR EVERY LOAD.
FREESPAC	28/3	WHEN CORE SPACE IS RELEASED BY AN MTS JOB THE STORAGE INDEX NUMBER IS GIVEN IN BYTE 9 AND THE NUMBER OF BYTES RELEASED IS GIVEN IN BYTES 10-12.

NAME	ID/LEN	DESCRIPTION
GETSPACE	29/3	THE SAME INFORMATION IS GIVEN WHENEVER CORE SPACE IS REQUESTED BY AN MTS JOB.
DSRIN	30/2	WHEN A DEVICE SUPPORT ROUTINE IS ENTERED THE MINIMUM TWO-WORD ITEM IS GIVEN FOR AN INPUT LINE, AND FOR AN OUTPUT LINE THE FOLLOWING: BYTES 9-12 CONTAIN THE FILE OR DEVICE NAME. BYTE 13 CONTAINS THE CURRENT PREFIX CHARACTER. THE FIRST BYTE OF THE FDUB (INCLUDING A BIT FOR INPUT OR OUTPUT) IS GIVEN IN BYTE 14. BYTES 15-16 CONTAIN THE LENGTH OF THE I/O MESSAGE, AND BYTES 17-20 CONTAIN THE FIRST FOUR CHARACTERS. THIS INFORMATION IS CURRENTLY COLLECTED ONLY FOR I/O FOR DEVICES (NOT FILES), AND NOT FOR LINES WITH A PREFIX CHARACTER OF . (INDICATING LOADING).
DSROUT	31/5	WHEN A DEVICE SUPPORT ROUTINE IS EXITED, THE MINIMUM ENTRY IS GIVEN FOR AN OUTPUT LINE, AND THE ITEM WHICH IS DESCRIBED ABOVE FOR OUTPUT LINES AT DSRIN IS GIVEN AT DSROUT FOR INPUT LINES.
DSROUT	31/7	IF AN INPUT LINE BEGINS WITH THE CHARACTERS $SIG THEN TWO ADDITIONAL WORDS (8 CHARACTERS) OF THE LINE ARE GIVEN IN BYTES 21-28.

APPENDIX B

APPENDIX B

```
$RUN *MOUNT PAR=S390 9TP, *STAT*, SIZE=4096, 'MASTER DATA TAPE',-
     RING OUT.

$RUN *ANALYSIS SCARDS=*STAT* SPRINT=*SINK*@MCC PAR=OPTN=1,-
     SFIL=2.SREC=15,CITM=520,ITMS=0,23,JOBS=ALL
```

(The above run converts only overflow and mark items from all the jobs referenced in the first 520 items beginning with the 16th record of the third file on the tape S390. The formatted original data items only are printed.)

APPENDIX C

APPENDIX C

```
JOBINFO  DSECT                  INFORMATION FOR ONE JOB
STATE    DS    C                CURRENT STATE OF JOB
TIMEBYTE DS    C                TIMER BYTE FOR CURRENT EVENT
DEVICE   DS    H                DEVICE NUMBER OF UNIT CAUSING LAST WAIT
TIMEWORD DS    F                TIMER WORD FOR CURRENT EVENT
JOBSEQID DS    H                SEQUENCE NUMBER FOR JOB
ITEMID   DS    H                SEQUENCE NUMBER FOR ITEM
OLDSTATE DS    C                LAST STATE JOB WAS IN
OLDTBYTE DS    C                NEXT TO LAST TIMER BYTE
JOBNO    DS    H                JOB NUMBER FOR JOB
OLDTIMER DS    F                NEXT TO LAST TIMER WORD
FDNAME   DS    F                NAME OF DEVICE BEING WAITED FOR
PREFIX   DS    C                PREFIX CHARACTER
IOBYTE   DS    C                INPUT OR OUTPUT BYTE
IOLENGTH DS    H                LENGTH OF LINE RELAYED
IOLINE   DS    3F               FIRST CHARACTERS OF LINE
GTSW     DS    H                SWITCH FOR GETSPACE ITEM
FRSW     DS    H                SWITCH FOR FREESPACE ITEM
LDSW     DS    H                SWITCH FOR LOAD ITEM
UNSW     DS    H                SWITCH FOR UNLOAD ITEM
GETSP    DS    F                SPACE GOT IN ONE INTERVAL
.RESP    DS    F                SPACE UNGOT IN ONE INTERVAL
SPTMINT  DS    F                SPACE-TIME INTEGRAL FOR VIRTUAL MEMORY
HPTOD    DS    F                LAST TOD WHEN THE HALF PAGE COUNT CHANGED
HPAGES   DS    F                CURRENT NUMBER OF VIRTUAL MEMORY PAGES
PAGEIN   DS    C                COUNT OF NUMBER OF PAGE-N OPERATIONS
                                      GOING
MARKBYTE DS    C                TIMER BYTE FOR MARK ITEM
LASTTYPE DS    C                TYPE OF LAST PAGING ENTRY
REALPAGE DS    C                NUMBER OF REAL CORE PAGES BEING USED NOW
MARKWORD DS    F                TIMER WORD FOR MARK ITEM
LDNME    DS    4F               NAME OF PROGRAM LOADED
UNNME    DS    4F               NAME OF PGM UNLOADED
WAYTQADD DS    F                ADDRESS OF NEXT WAYTQ ENTRY
WAYTQ    DS    12F              WAYT Q
INUSE    DS    C                USAGE FLAG FOR THIS JOB AREA
CPUQINDX DS    C                INDEX OF CURRENT CPU Q ENTRY
VALID    DS    C                VALID STATE KNOWLEDGE SWITCH
DSRSW    DS    C                DEVICE SUPPORT ROUTINE SWITCH
JOBEND   EQU   *                END OF A JOB INFO AREA
*
*    PAGE AREA
*
PAGETABL DSECT
TLE      DS    C                TYPE OF LAST ENTRY
TB       DS    C                TIMER BYTE
JBNO     DS    H                JOB NUMBER
TW       DS    F                TIMER WORD
RCA      DS    H                REAL CORE ADDRESS
VMA      DS    H                VIRTUAL MEMORY ADDRESS
PIC      DS    H                PAGE-IN COMPLETED COUNT
RCC      DS    H                PAGE REALLY RECLAIMED COUNT
CMSEC    DS    F                TIME IN CORE
DMSEC    DS    F                TIME ON THE DRUM
```

APPENDIX D

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NAME	JOB	MICROSEC	ITEM IN HEXADECIMAL...				
QUEUE	12	118183815	3225000C	01088A7F	0F080051		
QUEUE	72	118184036	32360048	01088A7F	092A000C		
QUEUE	12	118186028	32CF000C	01088A7F	0E000048		
QUEUE	3	118201614	327C0003	01088A84	092A000C		
QUEUE	12	118202187	32A8000C	01088A84	01080003		
QUEUE	3	118247304	32310003	01088A92	092A000C		
QUEUE	14	118248033	3269000F	01088A92	01080003		
ADDTOTOP	14	118249127	128D000E	01088A92	0C0054FC		
POPQUEUE	14	118250325	1419000E	01088A93	480056F4		
UNWAYT	14	118250520	2A28000F	01088A93	00000000		
DSROUT	14	118253359	F902000E	01088A94			
DSRIN	14	118254986	F47F000F	01088A94	03C1F1F2	6F400012	89E2D7D9
WAYT	14	118255416	23A0000E	01088A94	004800FF	6110101C	
QUEUE	3	118255768	32B80003	01088A94	0822000E		
PAGOUTST	15	118256536	54F6000F	01088A94	007D010D	0C000410	16820510
PAGOUTST	15	118256666	5400000F	01088A95	0037010F	04000410	16820713
PAGOUTST	4	118256796	540A0004	01088A95	00400115	02011010	16830216
PAGOUTST	15	118256940	5415000F	01088A95	003401CA	0C000410	14830911
PAGOUTDN	15	118257617	5C49000F	01088A95	0034010A	0C000410	14030911
QUEUE	13	118260026	32020000	01088A96	01000003		
PAGINDON	13	118260117	4C090000	01088A96	003C0107	2C011410	14070316
PAGINSTR	13	118261328	44660000	01088A96	00700114	48011410	10050224
QUEUE	12	118261880	32910000	01088A96	0A32000D		
QUEUE	3	118303945	322F0003	01088AA3	092A000C		
QUEUE	12	118304531	325C000C	01088AA3	01080003		
QUEUE	3	118327893	325E0003	01088AAA	092A000C		
PAGOUTDN	15	118328489	5C8C000F	01088AAA	007D010D	0C00031C	16030518
PAGOUTDN	15	118328893	5CAB000F	01088AAA	0037010F	04000210	16030608
PAGOUTDN	4	118329283	5CC90004	01088AAA	00400115	00011010	16030718
PAGOUTST	4	118330338	541A0004	01088AAB	00710116	03010F1C	1683032A
QUEUE	4	118332604	32C80004	01088AAB	01000003		
PAGINDON	4	118332695	4CCF0004	01088AAB	0074010F	24010F1C	16070410
PAGINSTR	4	118333776	4422C004	01088AAC	00530102	4C010F1C	16050429
QUEUE	12	118334375	32500000	01088AAC	02320004		
QUEUE	3	118372226	32AB0003	01088AB7	092A000C		
QUEUE	12	118372812	32D80000	01088AB7	01080003		
QUEUE	72	118374492	32590048	01088AB9	092A000C		
QUEUE	12	118376276	32E20000	01088AC0	0E000048		
QUEUE	72	118376484	32F20048	01088AB8	092A000C		
QUEUE	12	118376848	32DF000C	01088A89	0E000048		
QUEUE	72	118383541	32100048	01088ABB	092A000C		
QUEUE	12	118385546	32AA000C	01088ABB	0E000048		
QUEUE	9	118401835	32B00009	01088AC0	092A000C		
UNWAYT	9	118403619	2A160009	01088AC1	00000000		
QUEUE	28	118403906	322C001C	01088AC1	06280009		
QUEUE	9	118407421	323A0009	01088AC2	1220001C		
WAYT	9	118411236	235F0009	01088AC3	000F0214	0101FC74	
QUEUE	12	118411614	32700000	01088AC3	06200009		
QUEUE	3	118414648	32650003	01088AC4	092A000C		
PAGOUTDN	4	118415273	5C950004	01088AC4	00710116	0001CF1C	1603C811
PAGOUTST	4	118416315	54E50004	01088AC4	00690100	04010F1C	16830210
QUEUE	13	118418593	32940000	01088AC5	01000003		
PAGINDON	13	118418684	4C980000	01088AC5	00400114	28011510	10070224
PAGINSTR	13	118419674	44E70000	01088AC5	00470116	4C011510	1205080F
QUEUE	12	118420234	32120000	01088AC6	0A320000		
QUEUE	28	118428177	32740010	01088AC8	092A000C		
QUEUE	12	118430130	32A0000C	01088AC9	122A001C		
QUEUE	0	118451914	32930000	01088ACF	092A000C		

Figure 1. A sample of the data items on the tape written by STAT, and annotated by the analysis program. The "Microsec" column is simply the decimal value of the low-order three bytes of the timer, converted to microseconds.

TASK	JOB	STATE	MICROSEC	ITEM	WAIT	DEV	EQNAME	I/O	LENGTH	PFX	LINE
****** THE RECORDING DATE WAS 03-21-68 AND THE TIME WAS 15:29.27											
1	19	UNSURE	10657643	1	UNKN	0000		00	0		
1	19	ACTIVE	1614	2	VMPAGES=	0					
1	19	UNSURE	51197	3	UNKN	0000		00	0		
1	19	ACTIVE	4023	4	VMPAGES=	0					
1	19	WAIT	2513	5	¬I/O	00FF		00	0		
1	19	ACTIVE	5494	6	VMPAGES=	0					
1	19	UNSURE	14067565	7	¬I/O	00FF		00	0		
1	19	ACTIVE	3750	8	VMPAGES=	0					
1	19	PAGEWAIT	41718	9							
1	19	ACTIVE	7343	10	VMPAGES=	0					
1	19	PAGEWAIT	43750	11							
1	19	ACTIVE	11302	12	VMPAGES=	4	GET= 4968				
1	19	WAIT	58910	13	I/O	0217		00	16		$SIG
1	19	ACTIVE	3724	14	VMPAGES=	4					
1	19	WAIT	24335	15	I/O	0217		00	16		$SIG
1	19	ACTIVE	2356	16	VMPAGES=	4					
1	19	READY	2651	17							
1	19	ACTIVE	5455	18	VMPAGES=	4					
1	19	WAIT	31132	19	I/O	0217		00	16		$SIG
1	19	ACTIVE	3033	20	VMPAGES=	4					
1	19	WAIT	11137	21	I/O	0217		00	16		$SIG
1	19	ACTIVE	3502	22	VMPAGES=	4					
1	19	READY	2669	23							
1	19	ACTIVE	7486	24	VMPAGES=	5	GET= 2136				
1	19	READY	2291	25							
1	19	ACTIVE	10203	26	VMPAGES=	5					
1	19	READY	5260	27							
1	19	ACTIVE	3919	28	VMPAGES=	5					
1	19	WAIT	15260	29	I/O	0217		00	16		$SIG
1	19	ACTIVE	1835	30	VMPAGES=	5					
1	19	READY	2356	31							
1	19	ACTIVE	5156	32	VMPAGES=	6	GET= 3632	FREE= 432			
1	19	READY	1731	33							
1	19	ACTIVE	221	34	VMPAGES=	6					

Figure 2. A sample of the normal printed output of the analysis program, showing the intervals of execution (ACTIVE), queueing for CPU (READY), and I/O and page waits.

TASK	JOB	STATE	MICROSEC	% TIME CORE-RES.	NO. OF PAGE-IN	NO. OF RECLAIM	LAST PAGING OPERATION
1	4	PAGINSTR	1343033	49.391746	2	0	PAGOUTQN
8	13	PAGOUTST	4122745	82.955658	2	1	PAGINDQN
8	13	PAGOUTST	5933333	81.397014	2	1	PAGINDQN
8	13	PAGOUTQN	2933	82.854329	2	1	PAGOUTST
4	9	PAGINDQN	189993	15.911059	1	0	PAGINSTR
4	9	PAGINSTR	1179967	11.360752	1	0	PAGOUTQN
8	13	PAGOUTQN	133384	81.551663	2	1	PAGOUTST
8	13	PAGOUTST	4333998	64.426855	2	0	PAGINDQN
8	13	PAGOUTQN	2993	64.427968	2	0	PAGOUTST
1	4	PAGINDQN	230364	60.303000	3	0	PAGINSTR
8	13	PAGINDQN	299978	78.166781	3	1	PAGINSTR
8	13	PAGINSTR	1996	64.406499	2	0	PAGOUTQN
1	4	PAGINSTR	523350	61.850389	3	0	PAGOUTQN
8	13	PAGOUTST	5933991	85.994491	2	2	PAGRECLM
8	13	PAGOUTST	4853367	80.954289	4	0	PAGINDQN
4	9	PAGINDQN	173353	12.576066	2	0	PAGINSTR
4	9	PAGINSTR	2153337	38.468259	2	0	PAGOUTQN
8	13	PAGOUTQN	73964	85.118574	2	2	PAGOUTST
8	13	PAGOUTQN	73977	80.109679	4	0	PAGOUTST
8	13	PAGOUTST	4773389	92.258274	2	0	PAGINDQN
1	4	PAGINDQN	170335	62.475949	4	0	PAGINSTR
8	13	PAGINDQN	173988	64.892505	3	0	PAGINSTR
8	13	PAGINSTR	293317	81.128373	2	1	PAGOUTQN
1	4	PAGINSTR	883001	50.335122	3	0	PAGOUTQN
8	13	PAGOUTQN	73979	92.358323	2	0	PAGOUTST
8	13	PAGOUTST	4513073	41.979390	2	0	PAGINDQN
8	13	PAGOUTQN	2993	41.971961	2	0	PAGOUTST
8	13	PAGOUTST	4433954	93.537256	4	0	PAGINDQN
8	13	PAGOUTQN	2993	93.537426	4	0	PAGOUTST
4	9	PAGINDQN	153078	30.474717	3	0	PAGINSTR
4	9	PAGINSTR	1163944	11.082336	1	0	PAGOUTQN
8	13	PAGOUTST	4353384	84.782323	4	0	PAGINDQN
8	13	PAGOUTQN	2990	84.782715	4	0	PAGOUTST
1	4	PAGINDQN	153043	59.824463	4	0	PAGINSTR
8	13	PAGINDQN	163953	81.345149	3	1	PAGINSTR

Figure 3. The normal paging data displayed by the analysis program. Included are the current paging action, the last previous action for that page, the percentage of time the page has been core-resident, etc.

```
  TAPE RECORD 1          SEL. ITEM 0          ITEM 0          RECORDED AT 16:03.09
****** THE RECORDING DATE WAS 01-09-68  AND THE TIME WAS 16:03.09
  TAPE RECORD 2          SEL. ITEM 70         ITEM 293        RECORDED AT 16:03.10
  TAPE RECORD 3          SEL. ITEM 173        ITEM 561        RECORDED AT 16:03.12
  TAPE RECORD 4          SEL. ITEM 248        ITEM 808        RECORDED AT 16:03.13
  TAPE RECORD 5          SEL. ITEM 308        ITEM 1080       RECORDED AT 16:03.14
  TAPE RECORD 6          SEL. ITEM 356        ITEM 1323       RECORDED AT 16:03.15
  TAPE RECORD 7          SEL. ITEM 395        ITEM 1585       RECORDED AT 16:03.16
  TAPE RECORD 8          SEL. ITEM 468        ITEM 1856       RECORDED AT 16:03.18
  TAPE RECORD 9          SEL. ITEM 576        ITEM 2144       RECORDED AT 16:03.19
  TAPE RECORD 10         SEL. ITEM 668        ITEM 2405       RECORDED AT 16:03.21
  TAPE RECORD 11         SEL. ITEM 759        ITEM 2677       RECORDED AT 16:03.22
  TAPE RECORD 12         SEL. ITEM 820        ITEM 2945       RECORDED AT 16:03.24
  TAPE RECORD 13         SEL. ITEM 870        ITEM 3204       RECORDED AT 16:03.25
  TAPE RECORD 14         SEL. ITEM 913        ITEM 3479       RECORDED AT 16:03.26
  TAPE RECORD 15         SEL. ITEM 960        ITEM 3746       RECORDED AT 16:03.27
  TAPE RECORD 16         SEL. ITEM 1019       ITEM 4010       RECORDED AT 16:03.29
  TAPE RECORD 17         SEL. ITEM 1061       ITEM 4285       RECORDED AT 16:03.30
  TAPE RECORD 18         SEL. ITEM 1158       ITEM 4570       RECORDED AT 16:03.32
  TAPE RECORD 19         SEL. ITEM 1214       ITEM 4830       RECORDED AT 16:03.33
  TAPE RECORD 20         SEL. ITEM 1268       ITEM 5082       RECORDED AT 16:03.34
  TAPE RECORD 21         SEL. ITEM 1302       ITEM 5341       RECORDED AT 16:03.35
  TAPE RECORD 22         SEL. ITEM 1345       ITEM 5598       RECORDED AT 16:03.36
  TAPE RECORD 23         SEL. ITEM 1382       ITEM 5878       RECORDED AT 16:03.37
  TAPE RECORD 24         SEL. ITEM 1458       ITEM 6169       RECORDED AT 16:03.39
  TAPE RECORD 25         SEL. ITEM 1521       ITEM 6447       RECORDED AT 16:03.40
  TAPE RECORD 26         SEL. ITEM 1554       ITEM 6747       RECORDED AT 16:03.42
  TAPE RECORD 27         SEL. ITEM 1597       ITEM 7031       RECORDED AT 16:03.44
  TAPE RECORD 28         SEL. ITEM 1636       ITEM 7302       RECORDED AT 16:03.45
  TAPE RECORD 29         SEL. ITEM 1689       ITEM 7601       RECORDED AT 16:03.46
  TAPE RECORD 30         SEL. ITEM 1748       ITEM 7903       RECORDED AT 16:03.48
  TAPE RECORD 31         SEL. ITEM 1818       ITEM 8182       RECORDED AT 16:03.49
  TAPE RECORD 32         SEL. ITEM 1877       ITEM 8452       RECORDED AT 16:03.50
  TAPE RECORD 33         SEL. ITEM 1953       ITEM 8738       RECORDED AT 16:03.51
  TAPE RECORD 34         SEL. ITEM 2016       ITEM 9002       RECORDED AT 16:03.53
  TAPE RECORD 35         SEL. ITEM 2091       ITEM 9274       RECORDED AT 16:03.54
  TAPE RECORD 36         SEL. ITEM 2150       ITEM 9537       RECORDED AT 16:03.55
  TAPE RECORD 37         SEL. ITEM 2241       ITEM 9790       RECORDED AT 16:03.56
  TAPE RECORD 38         SEL. ITEM 2310       ITEM 10059      RECORDED AT 16:03.57
  TAPE RECORD 39         SEL. ITEM 2357       ITEM 10324      RECORDED AT 16:03.59
  TAPE RECORD 40         SEL. ITEM 2404       ITEM 10570      RECORDED AT 16:04.00
```

Figure 4. The tape inventory lines produced by the analysis program. The given time is that of the first data item in the record described.

ITEM FREQUENCY DATA

ITEM TYPE	TOTAL COUNT	NO. SELECTED
OVERFLOW	0	0
GATE	1	1
ADDTOTCP	5153	5153
POPQUEUE	5029	5026
WAYT	88646	88646
UNWAYT	88638	88638
QUEUE	501130	501129
STATSW	17	17
PAGINSTR	26982	26982
PAGINDON	26984	26984
PAGOUTST	28594	28594
PAGOUTON	27477	27477
PAGRECLM	5269	5269
GETVMPAG	5906	5906
FREVMPAG	6068	6068
********	0	0
********	0	0
********	0	0
********	0	0
********	0	0
********	0	0
********	0	0
********	0	0
PARK	0	0
VMPAGES	5106	5105
WAITFOR	77	77
UNLOAD	264	264
LOAD	262	262
FREESPAC	11912	11912
GETSPACE	11840	11840
DSRIN	18352	18352
DSROUT	18341	18341
	882048	882026

Figure 5. The item summary sheet printed by the analysis program, showing the number of each type of data item encountered and selected for processing.

TABLE OF DEVICE NUMBERS AND I/O COUNTS....

DEVICE 00000214	WAITS=4011
DEVICE 00000215	WAITS=5575
DEVICE D3C1F0F7	WAITS=655
DEVICE D3C1F1F3	WAITS=379
DEVICE D3C1F1F4	WAITS=435
DEVICE 00000216	WAITS=23
DEVICE 400078C9	WAITS=79
DEVICE 0110101C	WAITS=128
DEVICE D7E3D9F1	WAITS=4933
DEVICE 00000210	WAITS=48
DEVICE 01101020	WAITS=10
DEVICE D7C3C8F1	WAITS=142
DEVICE D3C1F1F1	WAITS=186
DEVICE 000000C5	WAITS=18
DEVICE C4C3F0F2	WAITS=3
DEVICE 00000014	WAITS=18
DEVICE 00000213	WAITS=8789
DEVICE 400078D5	WAITS=211
DEVICE 20101010	WAITS=123
DEVICE D3C1F0F8	WAITS=307
DEVICE 80000746	WAITS=54
DEVICE C4C3F0F1	WAITS=75
DEVICE 4000788D	WAITS=445
DEVICE C4C3F0F0	WAITS=649
DEVICE 00000044	WAITS=5
DEVICE D9C4D9F1	WAITS=2465
DEVICE 60101022	WAITS=537
DEVICE 00000041	WAITS=1
DEVICE 00000011	WAITS=79
DEVICE 0101CFB6	WAITS=8
DEVICE D3C1F0F4	WAITS=124
DEVICE 00000217	WAITS=22321
DEVICE D3C1F1F2	WAITS=252
DEVICE D3C1F0F9	WAITS=221
DEVICE 400078FD	WAITS=3191
DEVICE 00000212	WAITS=38
DEVICE 00000211	WAITS=36
DEVICE 6110101C	WAITS=113
DEVICE D3C1F1F0	WAITS=347
DEVICE 00000043	WAITS=5
DEVICE 00000030	WAITS=47
DEVICE D3C1F0F1	WAITS=179
DEVICE D7E3D9F2	WAITS=343
DEVICE E3F0C3F5	WAITS=24
DEVICE 00000042	WAITS=1
DEVICE 80015584	WAITS=1

Figure 6. A table of "devices" produced by a subroutine receiving output from the analysis program. Given are the number of I/O waits for each "device." The name of a "device" is

a. a halfword device number,
b. a device name (e.g., PTR3),
c. an address in the supervisor or device support routines where an I/O queue is processed.

```
*USERS              LOADED BY JOB   25 TASK   59
*ASMG               LOADED BY JOB   23 TASK   61
*ASMG               LOADED BY JOB   23 TASK   61
*ASMG               LOADED BY JOB   23 TASK   61
*ASMG               LOADED BY JOB   23 TASK   61
FREDONE             LOADED BY JOB   68 TASK   33
S005OBJECTSCAN      LOADED BY JOB   14 TASK   60
*ASMG               LOADED BY JOB   23 TASK   61
*ASMERR             LOADED BY JOB   23 TASK   61
<SF>0012LOAD#       LOADED BY JOB   12 TASK    9
*PIL                LOADED BY JOB   25 TASK   59
*CATALOG            LOADED BY JOB   14 TASK   60
<SF>0013LOAD#       LOADED BY JOB   13 TASK   52
*USERS              LOADED BY JOB   46 TASK   43
*FILESCAN           LOADED BY JOB   20 TASK   17
*NEWPORT            LOADED BY JOB   23 TASK   61
JOB   40 TASK   78 CPU TIME      .041615 ELAPSED TIME     358.904
                   CPU TIME VMI      .208073 ELAPSED TIME VMI     1794.519 WAIT STATE VMI     1794.311
                   CPU TIME RCI      .108763 ELAPSED TIME RCI     361.278698 DRUM READS    6
*BASR               LOADED BY JOB   46 TASK   43
*DEARBATCH          LOADED BY JOB   17 TASK   14
JOB   41 TASK   72 CPU TIME      .144102 ELAPSED TIME      45.851
                   CPU TIME VMI      .847617 ELAPSED TIME VMI      230.112 WAIT STATE VMI      229.265
                   CPU TIME RCI      .628060 ELAPSED TIME RCI     104.888320 DRUM READS    4
```

Figure 7. A sample page of output from a subroutine written to assist in determining equable billing algorithms.

```
****** THE RECORDING DATE WAS 01-22-68  AND THE TIME WAS 13:31.13
    DURING THE LAST     60267813 MICROSECONDS, THE CPU WAS IDLE FOR     49979948 MICROSECONDS, OR AN IDLE PERCENTAGE OF    82.9300
    DURING THE LAST     60026977 MICROSECONDS, THE CPU WAS IDLE FOR     43119699 MICROSECONDS, OR AN IDLE PERCENTAGE OF    71.8300
    DURING THE LAST     60000727 MICROSECONDS, THE CPU WAS IDLE FOR     31092060 MICROSECONDS, OR AN IDLE PERCENTAGE OF    51.8200
    DURING THE LAST     60015999 MICROSECONDS, THE CPU WAS IDLE FOR     25579438 MICROSECONDS, OR AN IDLE PERCENTAGE OF    42.6200
    DURING THE LAST     60000714 MICROSECONDS, THE CPU WAS IDLE FOR     19197935 MICROSECONDS, OR AN IDLE PERCENTAGE OF    32.0000
    DURING THE LAST     60006105 MICROSECONDS, THE CPU WAS IDLE FOR     31602158 MICROSECONDS, OR AN IDLE PERCENTAGE OF    52.6600
    DURING THE LAST     60000279 MICROSECONDS, THE CPU WAS IDLE FOR     35109545 MICROSECONDS, OR AN IDLE PERCENTAGE OF    58.5200
    DURING THE LAST     60009900 MICROSECONDS, THE CPU WAS IDLE FOR     32114985 MICROSECONDS, OR AN IDLE PERCENTAGE OF    53.5200
    DURING THE LAST     60010291 MICROSECONDS, THE CPU WAS IDLE FOR     29224037 MICROSECONDS, OR AN IDLE PERCENTAGE OF    47.0300
    DURING THE LAST     60006505 MICROSECONDS, THE CPU WAS IDLE FOR     27422535 MICROSECONDS, OR AN IDLE PERCENTAGE OF    45.7000
    DURING THE LAST     60004665 MICROSECONDS, THE CPU WAS IDLE FOR     31577336 MICROSECONDS, OR AN IDLE PERCENTAGE OF    52.6200
    DURING THE LAST     60012619 MICROSECONDS, THE CPU WAS IDLE FOR     36235131 MICROSECONDS, OR AN IDLE PERCENTAGE OF    60.3800
    DURING THE LAST     60000977 MICROSECONDS, THE CPU WAS IDLE FOR     45658873 MICROSECONDS, OR AN IDLE PERCENTAGE OF    76.1000
    DURING THE LAST     60000470 MICROSECONDS, THE CPU WAS IDLE FOR     45210422 MICROSECONDS, OR AN IDLE PERCENTAGE OF    75.3500
    DURING THE LAST     60009793 MICROSECONDS, THE CPU WAS IDLE FOR     34388811 MICROSECONDS, OR AN IDLE PERCENTAGE OF    57.3100


****** ONE INPUT FILE HAS BEEN PROCESSED.

          TOTAL NUMBER OF INPUT ITEMS =       110339

          TOTAL NUMBER OF MISSING ITEMS =          0

            CUMULATIVE AVERAGE CPU IDLE PERCENT =  57.3600  FOR A PERIOD OF     900.373 SECONDS.
```

Figure 8. The output of a subroutine to compute CPU utilization.

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13. ABSTRACT

A software system for obtaining computing system and program performance data is described. It includes programs for the collection of such data from the Michigan Terminal System (MTS) and its analysis to produce a general description of program behavior. Procedures for gathering data and using the analysis programs are given, along with examples of the output.

DD FORM 1 JAN 64 1473

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